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# First record of *Tridacna crocea* Lamarck, 1819 (Bivalvia, Cardiidae) from Patnanungan Island, Philippines

Jane Abigail Santiago[1*], Ma Carmen Ablan-Lagman[1]

1 Biology Department and Center for Natural Sciences and Environmental Research, De La Salle University, Manila, Philippines • JAS: jane_santiago @dlsu.edu.ph • MCAL: ma.carmen.lagman@dlsu.edu.ph

* Corresponding author

**Abstract**

We present a new record and information on the distribution of the IUCN listed *Tridacna crocea* Lamarck, 1819 in the Philippines. The new record in Patnanungan Island extends the known distribution of this species by 80 km east of the nearest previously known occurrence. The collected specimens are found in shallow water at a depth of 3 m, exhibit a relatively small size, and showed the characteristic of completely burrowing its valves in coral substrates. DNA barcoding was also done, and the constructed phylogenetic tree demonstrated that the giant clams created a monophyletic group. *Tridacna crocea* has a wide distribution and is relatively abundant throughout the Philippine reefs. We recommend updating the population status and stock assessment of giant clams in the country for local regulation and conservation management.

**Keywords**

Biodiversity, boring clam, crocus clam, DNA barcoding, giant clams

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## Introduction

Giant clams (Cardiidae: Tridacninae) belong to the list of the Convention on International Trade in Endangered Species (CITES) Appendix II and the International Union for Conservation (IUCN) Red List of Threatened Species. In the Philippines, giant clams are protected under the Philippine Fisheries code, Fisheries Administrative Order (FAO) 208 and Republic Act (RA) 8550, which prohibit the collection of living specimens for raw shells, meat consumption, and any byproducts of giant clams. The Philippine law only permits the collection of giant clams for research purposes where the proponent must abide with the requirements under the Fisheries Administrative Order 233. The FAO Order 233 allows research for giant clams if they are not taken from their habitat and ensure that they remain alive during the study. The rigorous processing of local and national permits for the collection of giant clams can take 1–3 years, particularly for marine protected areas. These prohibitions highlight the importance of giant clam conservation to Philippine marine biodiversity. The status of giant clams in the Philippines was assessed in 1989 (Junio et al. 1989) and included seven extant species which ranged from Endangered to Vulnerable. Five of these species belong to the genus *Tridacna* Bruguière, 1797 and two to the genus *Hippopus* Lamarck, 1799. *Tridacna crocea* Lamarck, 1819 is listed by the IUCN as of Least Concern, but in the Philippines this species is considered Endangered. Thus, discovery of thriving populations of these clams

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are important. There is no recent update on the conservation and population status of giant clams in the Philippines since 1989.

Polillo archipelago in the eastern Philippines consist of 27 islands with three major islands: Polillo, Patnanungan, and Jomalig. *Tridacna crocea* was reported to occur in Polillo Island more than 30 years ago by Junio et al. (1989) and more recently by Ravago-Gotanco et al. (2007). There are no records of either surveys or collection data from Patnanungan and Jomalig islands which are further off the Philippine Pacific seaboard. Here, we document a new record from Patnanungan Island, Quezon Province. This new record represents a small range extension of 80 km east of the nearest previously known occurrence.

## Materials and Methods

**Acquisition of permits.** Local and national CITES permits were acquired before specimen collection. The Philippines' Bureau of Fisheries and Aquatic Resources - Fisheries Quarantine and Wildlife Regulation Section of the Fisheries Regulatory and Quarantine Division under the Philippine National Government is the issuing office for National-Gratuitous Permits. The Gratuitous Permit No. 0203-20 was issued for this study.

The permit only allowed two giant clams to be collected and held during the collection of mantle tissue. After being sampled, he giant clams were returned to their natural habitat, and only the tissue samples for molecular analyses were allowed to be transferred to other locations. All standard methods according to the permit were followed accordingly.

**Collection of *Tridacna crocea*.** *Tridacna crocea* were collected using scuba equipment from Patnanungan Island, Quezon Province. Two live specimens were brought back to the wild after identified, measured using vernier calipers, and photographed with Fujifilm X-A2. A small, approximately 10–15 mm sample of mantle tissue was cut from each specimen for DNA barcoding analysis. A phosphate-buffered saline (1X-PBS) solution in a 1.5 ml microcentrifuge tube was used to preserve the sample tissues. All collected tissues are initially stored in an ice chest and later placed in a −20 °C freezer in the Practical Genomics Laboratory of De La Salle University.

The earliest record in the Philippines for *T. crocea* was from 1983 (Wells et al. 1983). Data from compiled literature from 1983 to now were used to ascertain the distribution of *T. crocea* in the Philippines. Data points from the Global Biodiversity Information Facility (GBIF 2020) and records from published literature were the basis of mapping the occurrences of *T. crocea* in the Philippines. SimpleMappr (Shorthouse 2010) was used to produce the map.

**Morphological characterization.** The shell size, boring nature, valve thickness, byssal gape, and shell margin characteristic were observed. Braley (1992), Naguit (2009), and Hernawan (2012) are the main literature used in describing the morphological characteristics of *T. crocea*.

**DNA extraction, PCR, and sequencing.** DNA was isolated from the mantle tissue of giant clam voucher specimens. DNA extractions were performed using 10% Chelex (biorad) solution (Walsh et al. 1991). A fragment of the mitochondrial cytochrome oxidase subunit I (COI) gene was amplified using the tridacnid specific primer (forwards: LCO: 5′-GGG TGA TAA TTC GAA CAG AA-3′; reverse: RCO: ′'-TAG TTA AAG CCC CAG CTA AA-3′) (Nuryanto et al. 2007). Polymerase chain reaction (PCR) reactions were performed in a total volume of 25 µL containing approximately: 1 µL DNA template, 17.1 µL ddH2O, 5 µL 5× Vivantis TaqBuffer, 1.5 µL 25MM MgCl2, 0.5 µL 10 MM dNTPs, 0.4 µL of each primers (10 µM). The amplified products were visualized on 1% agarose gel stained with ethidium bromide. PCR purified products were sent to Asiagel-Malaysia for bidirectional sequencing.

**Genetic analysis.** Nucleotide sequences were aligned using MUSCLE using default parameters. The aligned sequences were 426–480 bp long and free from gaps after trimming using ExPASy server (Gasteiger et al. 2003). All DNA sequences were deposited in GenBank under accession numbers MW582697 and MW581938. The sequences from the collected *T. crocea* were identified using NCBI-blast (Altschul et al. 1990). Additional sequences of *T. maxima*, *T. noae*, *T crocea*, and *T. squamosa* in the subgenus *Chametrachea* Herrmannsen, 1846, *Tridacna gigas* (Linnaeus, 1758) in the subgenus *Tridacna* Bruguière, 1797, *Hippopus Hippopus* (Linnaeus, 1758) were derived from Genbank. The DNA sequence of *Cerastoderma glaucum* (Bruguière, 1789) was used as the. Phylogenetic trees were constructed using Molecular Evolution Genetic Analysis (MEGA) v. 10.0 using the neighbor-joining method. Kimura's 2-parameter distance model was used to construct neighbor-joining trees.

## Results

We identified our two collected specimens as *Tridacna crocea* (Fig. 1) using both morphological and COI gene data. These specimens represent the first record of the genus *Tridacna* and of *T. crocea* from Patnanungan Island.

**New record.** PHILIPPINES • West Philippine Sea, Quezon Province, Polillo group of islands, Patnanungan Island; 14°48′00″N, 122°18′00″E; 3 m depth; 3-XII-2020; JAM Santiago leg; GenBank accession numbers MW582697 and MW581938

**Identification.** *Tridacna crocea* was recognized due to its habit of burrowing and completely embeds to hard coral heads (Hernawan 2012; Neo et al. 2015). *Tridacna*

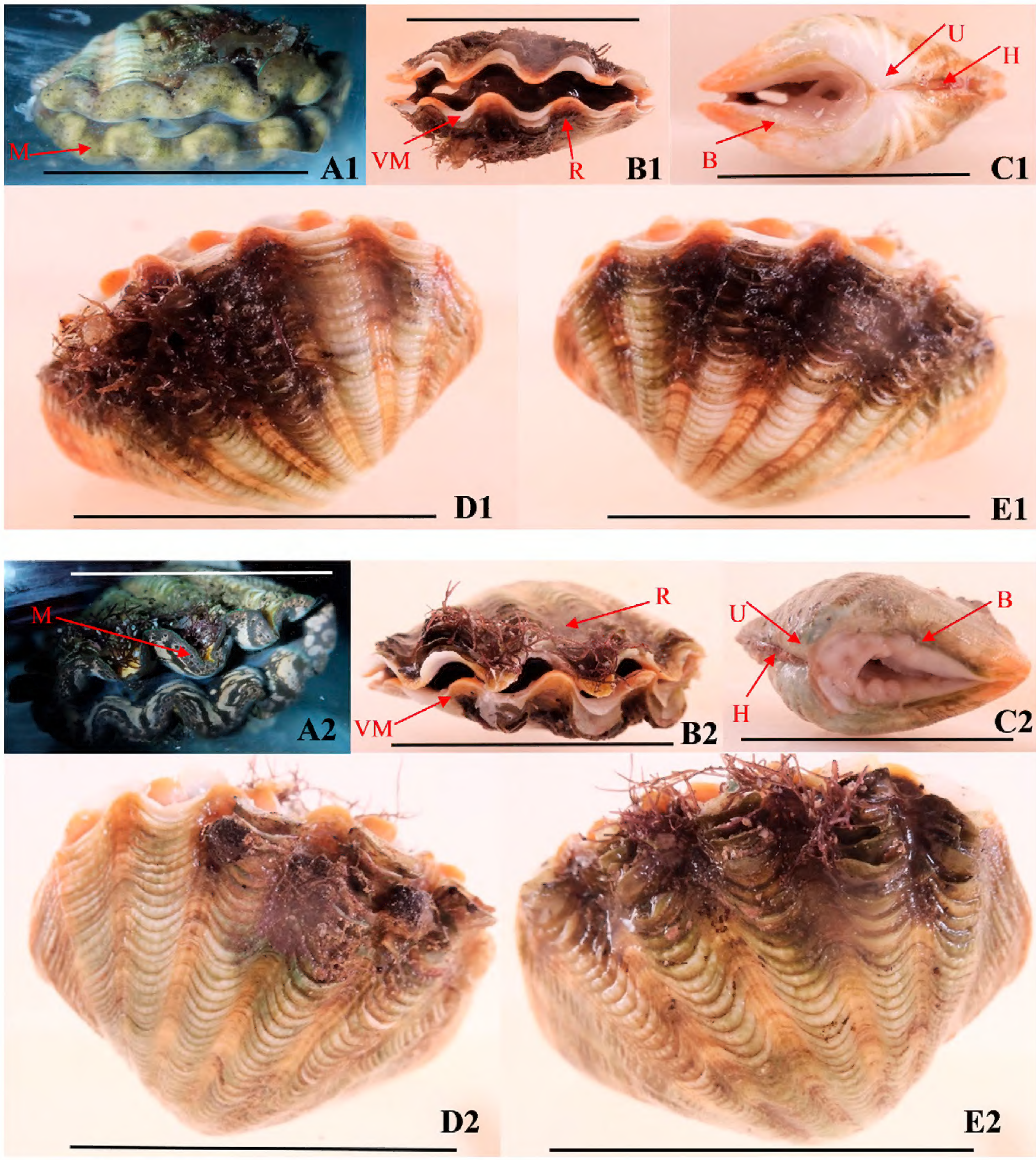


**Figure 1.** *Tridacna crocea* collected from Patnanungan Island. **A1, A2.** Mantle (M) view. **B1, B2.** Valve margins (VM) and rib (R) interstices view. **C1, C2.** Byssal gape (B), umbo (U) and hinge (H) line view. **D1, D2, E1, E2.** Lateral view. A1–E1 = specimen 1; A2–E2 = specimen 2. Scale bars: 50 mm.

*crocea* is relatively smaller size compared with other tridacnid species. The length of shells in this study are 62mm and 105 mm, which is within the range found in Palawan (10 mm–147.6 mm; Daño et al. 2020). The mantle was brownish. The other distinguishable characteristics of *T. crocea* are the following: the valve thickness is moderate, with swollen valve margins; there is a large byssal gape and the hinge line is less than half of the shell length; the outline of the shell is triangular-ovate; the outer shell sculpture consists of tattered, low but raised ribs and smooth toward umbos (Braley 1992); and there are scattered hyaline organs on the siphonal mantle (Naguit 2009).

## Discussion

*Tridacna crocea* has only been recorded in the Indo-Pacific Region, where it is widely distributed and abundant (Ravago-Gotanco et al. 2007; Huelsken et al. 2013) that have occurrences from Japan, Australia, Palau (Wells 1997) and Indonesia (Hernawan 2012). However, it is considered extinct in Guam and the Northern Marianas (Wells 1997). In the Philippines, *T. crocea* was

recorded from 55 localities since 1983 (Table 1). The Luzon group of islands has the most records of *T. crocea* among the 25 studies that has been conducted in the Philippines (Table 1; Fig. 2). The Palawan region has the most records of *T. crocea* that includes morphological and molecular characterization, distribution pattern, and population genetic structure. The list of occurrences (Table 1) show that *T. crocea* has a wide distribution in Philippines, and this species is relatively more abundant than other tridacnid species on Philippine reefs (Ravago-Gotanco et al. 2007; Dolorosa and Jontilla 2012). The current population density and distribution pattern of *T. crocea* in the Philippines need updating to allow for a proper recommendation to the local resource management and possible mariculture. Currently, all *Tridacna* species are Endangered in the Philippines. For *T. crocea*, this status may be possible to change to Vulnerable or Least Concern status if population density and

**Table 1.** Updated list of *Tridacna crocea* Lamarck, 1819 occurrences in the Philippines.

| Island group | Locality | Reference | Remarks |
|---|---|---|---|
| Luzon | Palawan Regions | Wells et al. 1983 | Inventory |
| | | Alcala 1986 | Inventory |
| | | Gomez and Alcala 1988 | Inventory |
| | | Munro 1989 | Inventory |
| | Cagayancillo, Palawan | Juinio et al. 1989 | Inventory |
| | Western Pangasinan | Juinio et al. 1989 | Inventory |
| | Polillo Island | Juinio et al. 1989 | Inventory |
| | | Ravago-Gotanco et al. 2007 | Population genetics |
| | Zambales | Juinio et al. 1989 | Inventory |
| | Albay | Juinio et al. 1989 | Inventory |
| | Sorsogon | Juinio et al. 1989 | Inventory |
| | Calatagan, Batangas | Juinio et al. 1989 | Inventory |
| | Lubang Island | Juinio et al. 1989 | Inventory |
| | Apo Reef | Juinio et al. 1989 | Inventory |
| | Puerto Galera | Juinio et al. 1989 | Inventory |
| | El Nido, Palawan | Juinio et al. 1989 | Inventory |
| | Tubbataha Reef, Palawan | Estacion et al. 1993 | Inventory |
| | | Calumpong and Cadiz 1993 | Inventory |
| | | Yamaguchi 1996 | Inventory |
| | | Yu et al. 2000 | Genetic marker |
| | | Juinio-Menez et al. 2003 | Genetic marker & structure |
| | | Dolorosa and Schoppe 2005 | Inventory |
| | | Dolorosa and Jontila 2012 | Inventory |
| | | Dolorosa et al. 2015 | Inventory |
| | | Conales et al. 2015 | Morphology |
| | Linapacan Strait in northern Palawan | Juinio-Menez et al. 2003 | Genetic marker & structure |
| | the Balabac Strait in southern Palawan | Juinio-Menez et al. 2003 | Genetic marker & structure |
| | Ulugan Bay, Palawan | DeBoer and Barber 2010 | Genetic marker |
| | | DeBoer et al. 2014 | Population genetics & structure |
| | | Santiago et al. 2020 | Phylogenetics |
| | Honday Bay, Palawan | DeBoer et al. 2014 | Population genetics & structure |
| | | Santiago et al. 2020 | Phylogenetics |
| | Romblon | DeBoer et al. 2014 | Population genetics & structure |
| | Apulit Island, Taytay, Palawan | Gonzales et al. 2014 | Inventory |
| | Saint Paul Bay, Western Palawan | Gonzales 2015 | Inventory |
| | Kalayaan island group | Juinio-Menez et al. 2003 | Genetic marker & structure |
| | Eastern Philippine Seaboard | Ravago-Gotanco et al. 2007 | Population genetics |
| | Cagayan Valley | Ravago-Gotanco et al. 2007 | Population genetics |
| | Isabela | Ravago-Gotanco et al. 2007 | Population genetics |
| | Aurora | Ravago-Gotanco et al. 2007 | Population genetics |
| | Catanduanes | Ravago-Gotanco et al. 2007 | Population genetics |
| | Masbate | Ravago-Gotanco et al. 2007 | Population genetics |
| | Spratly Islands | Naguit 2009 | Genetic markers |
| | Camarines | (DeBoer et al. 2014 | Population genetics & structure |
| | Batanes Island | Santiago et al. 2020 | Phylogenetics |
| | Rita Island | Daño et al. 2020 | Inventory |
| | Patnanungan Island, Quezon | This study (2021) | Morphology & DNA Barcoding |
| Visayas | Central and Western Visayas | Alcala 1986 | Inventory |
| | North East Negros | Juinio et al. 1989 | Inventory |
| | Sumilon Island Cebu | Calumpong and Cadiz 1993 | Inventory |
| | Balicasag Island, Bohol | Calumpong and Cadiz 1993 | Inventory |
| | Bolisong, Negros Occidental | Calumpong et al. 2002 | Inventory |
| | Balicuatro, Northern Samar | Ravago-Gotanco et al. 2007 | Population genetics |
| | Divinubo, Eastern Samar | Ravago-Gotanco et al. 2007 | Population genetics |
| | Homonhon, Eastern Samar | Ravago-Gotanco et al. 2007 | Population genetics |
| | Southeastern Samar | Naguit 2009 | Morphology & genetic markers |
| | | Naguit 2015 | Genetic markers |
| | Pamilacan, Bohol | Naguit 2009 | Morphology & genetic markers |
| | Tañon Strait | Naguit 2009 | Morphology & genetic markers |
| | | Naguit 2015 | Genetic markers |
| | Panglao, Bohol | ter Poorten 2009 | Inventory |
| | Carbin, Sagay, Negros Occidental | Naguit 2009 | Morphology & genetic markers |
| | | DeBoer et al. 2014 | Population genetics & structure |
| | Guian, Samar | DeBoer et al. 2014 | Population genetics & structure |
| | Bohol Sea | Naguit 2015 | Genetic markers |
| Mindanao | Cagayan, Sulu Sea | Alcala 1986 | Inventory |
| | | Calumpong and Cadiz 1993 | Inventory |
| | Camiguin Island | Juinio et al. 1989 | Inventory |
| | | Naguit 2009 | Morphology & genetic markers |
| | Dinagat Islands, Northern Mindanao | Ravago-Gotanco et al. 2007 | Population genetics |
| | | DeBoer et al. 2014 | Population genetics & structure |
| | Lianga, Surigao del sur | Ravago-Gotanco et al. 2007 | Population genetics |
| | Mati, Davao | Ravago-Gotanco et al. 2007 | Population genetics |
| | Tawi-Tawi | DeBoer et al. 2014 | Population genetics & structure |

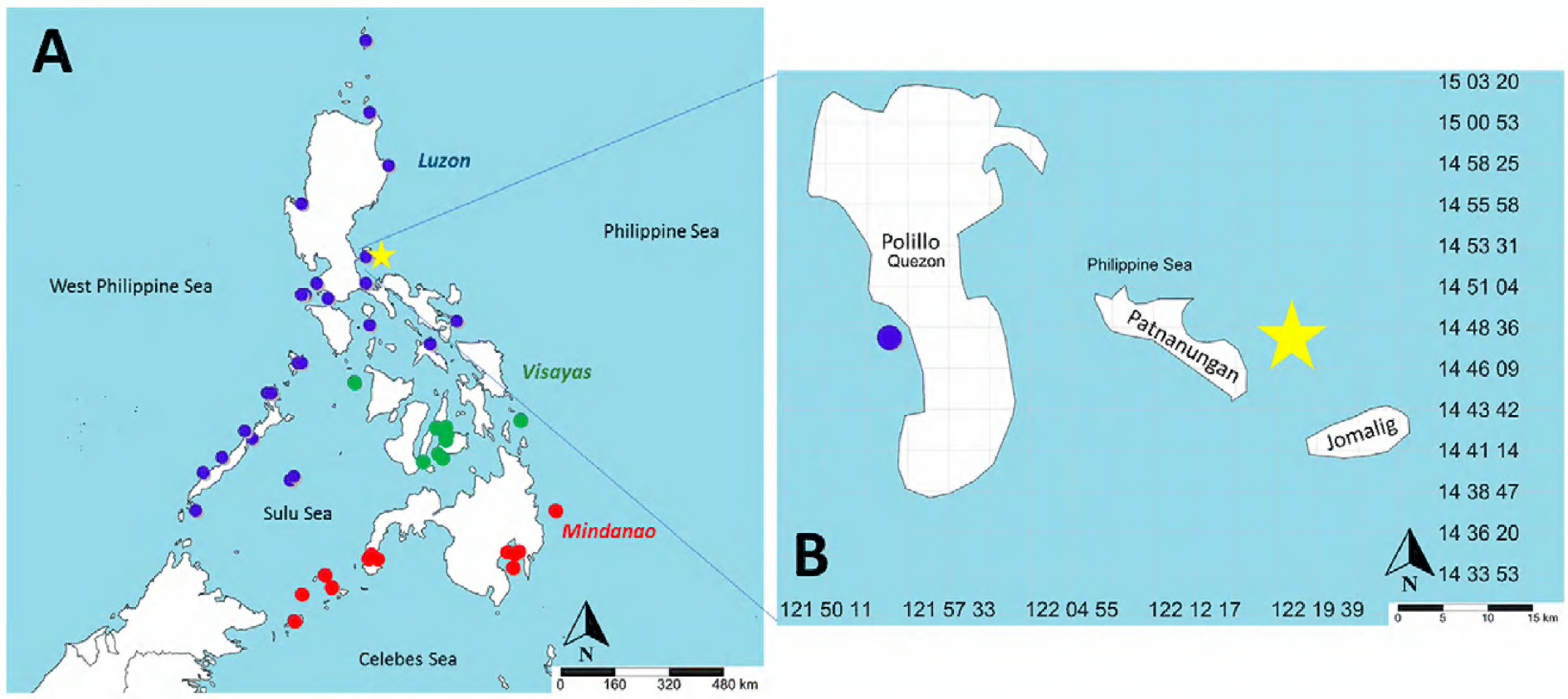


**Figure 2.** Distribution Map of *Tridacna crocea* in the Philippines. **A.** Occurrences in the Philippines where blue dots represent previous records in Luzon, green dots in Visayas, red dots in Mindanao. **B.** Map showing the 3 major islands of Polillo Group of Islands. Blue dot was the previous record while the yellow star is the new record by this study.

stock assessments are updated. Certainly, we still recommend that *T. crocea* remain protected under the law and by enforcement, but that regulated mariculture is promoted. Relatively smaller species, such as *T. crocea*, *T. maxima* (Röding, 1798), and *T. squamosa* Lamarck, 1819, are better option for mariculture because it only takes 5–7 months to grow to a size suitable for export (Foyle et al. 1997). Most of local people illegally collect wild *T. crocea* for their food consumption and for the aquarium trade (Gomez and Mingoa-Licuanan 2006; Gomez et al. 2006), but this could be lessened if regulated mariculture of this species was established.

*Tridacna crocea* was recorded from Polillo Island in 1989 and 2007, but there are no more recent records from this area. Since the last records, Polillo Island has become a popular tourist spot where the human population and congestion has increased (Lagbas and Habito 2016). Polillo Island is also a focal point where commercial fishes are marketed. The coastal community consumes giant clam meat during the typhoon and monsoon season when fishermen are prevented from going to the open sea. This happens in other areas of the Philippines, resulting in declining *Tridacna* populations (Gomez and Mingoa-Licuanan 2006; Lebata-Ramos et al. 2010). There was an effort made on Polillo Island to restock giant clams by the Local Government Unit (LGU) with University of the Philippines-Marine Science Institute (Gomez and Mingoa-Licuanan 2006; Gomez et al. 2006). Our new record of a *Tridacna* species in neighboring Patnanungan Island may be helpful to guide the LGU in conservation of *Tridacna* species in Quezon Province. Patnanungan Island, with lesser disturbances due to its smaller human population and lesser amount of tourism, could be an additional restocking site. The new record of *T. crocea* from Patnanungan Island will also help to give awareness and encouragement to *Tridacna* and other marine species in Patnanungan Island.

The genetics of giant clams in the Philippines have been given little attention. A recently rediscovered species, *Tridacna noae* (Röding, 1798), has been proposed to belong to subgenus *Chametrachea* which includes *T. squamosa*, *T. maxima*, *T. crocea*, and *T. noae*. There is ambiguity and confusion with the morphological identification of these species due to their similar size and shell pattern (Nuryanto et al. 2007; Naguit 2009). Although there several phylogenetic trees are available (Nuryanto et al. 2007), there are still uncertain relationships among tridacninae species, specifically in the subgenus *Chametrachea* (Nuryanto et al. 2007). We present a phylogenetic tree that includes all species of the subgenus *Chametrachea* to confirm the identification of the *T. crocea* on Patnanungan Island. Our phylogenetic tree also lends support to the claim that *T. noae* belongs to *Chametrachea*. In our phylogentic tree (Fig. 3), the two specimens collected for this study from Patnanungan Island grouped with other *T. crocea* sequences from GenBank. Giant clams form a monophyletic group in our tree, *T. crocea* is more closely related to *T. squamosa* than *T. noae*, and *T. maxima* is a sister group to the other three giant clams of the subgenus *Chametrachea* (Fig. 3).

A survey throughout the country to determine the population status and genetic diversity of the wild and restocked populations of giant clams is vital to assist the local conservation efforts and at the same time help establish sustainable mariculture which would provide economic and environmental benefits.

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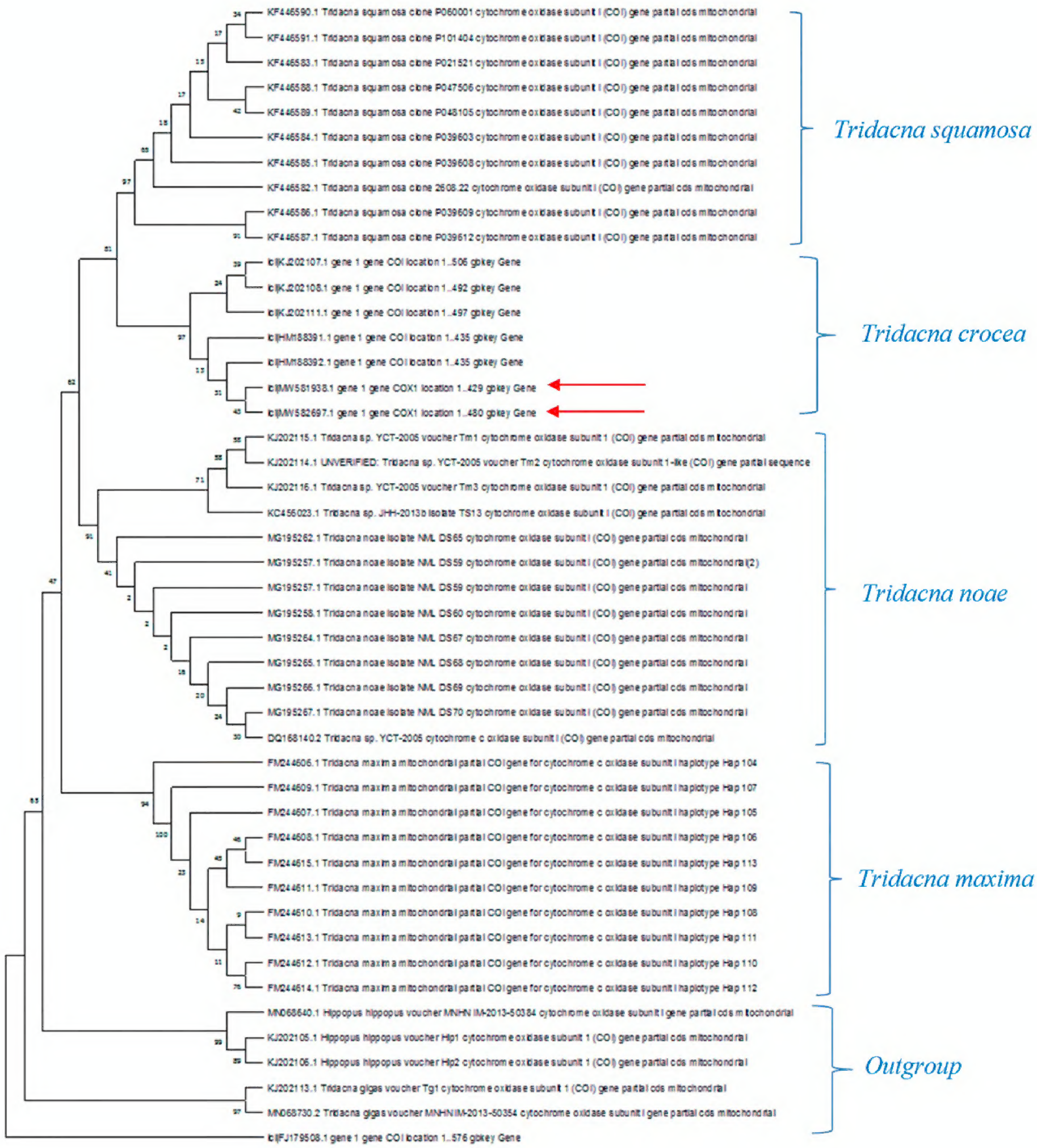


**Figure 3.** Phylogenetic tree of giant clams based on 400 bp of the mitochondrial DNA COI gene using the neighbor-joining method. Red arrows mark the two new records of *Tridacna crocea* from Patnanungan Island.

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## Author's Contribution

Conceptualization: JAS, MCAL. Data curation: JAS. Formal analysis: JAS, MCAL. Funding acquisition: MCAL. Project administration: MCAL. Software: JAS. Supervision: MCAL. Validation: MCAL. Visualization: JAS. Writing – original draft: JAS. Writing – review and editing: MCAL.

## References

Alcala AC (1986) Distribution and abundance of giant clams (Family Tridacnidae) in the South-Central Philippines. Silliman Journal 33: 1–9.

Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ (1990) Basic local alignment search tool. Journal of Molecular Biology 215: 403–410.

Braley RD (1992) The giant clam: hatchery and nursery culture manual. Australian Centre for International Agricultural Research Monographs 118699: 1–10.

Calumpong HP, Cadiz P (1993) Observations on the distribution of giant clams in protected areas. Silliman Journal 36: 107–116.

Calumpong HP, Apao AB, Lucañas JR, Estacion JS (2002) Commu-

nity-based giant clam restocking—hope for biodiversity conservation. In: Proceedings of the 9th International Coral Reef Symposium, Bali, Indonesia, 23–27.

Conales SF, Bundal NA, Dolorosa RG (2015) High density of *Tridacna crocea* in exposed massive corals proximate the ranger station of Tubbataha Reefs Natural Park, Cagayancillo, Palawan, Philippines. The Palawan Scientist 7: 36–39.

Daño JC, Villanueva EG, Dolorosa RG (2020) High density of *Tridacna crocea* in Rita Island, Puerto Princesa City, Palawan, Philippines. The Palawan Scientist 12: 159–163.

DeBoer TS, Barber PH (2010) Isolation and characterization of nine polymorphic microsatellite markers for the endangered boring giant clam (*Tridacna crocea*) and cross-species amplification in three other tridacnid species. Molecular Ecology Resources 2: 353–356. https://doi.org/10.1007/s12686-010-9249-7

DeBoer TS, Naguit M, Erdmann M, Ablan-Lagman M, Ambariyanto, Carpenter K, Toha AH, Barber P (2014) Concordance between phylogeographic and biogeographic boundaries in the Coral Triangle: conservation implications based on comparative analyses of multiple giant clam species. Bulletin of Marine Science 90 (1): 277–300. https://doi.org/10.5343/bms.2013.1003

Dolorosa RG, Schoppe S (2005) Focal benthic mollusks (Mollusca: Bivalvia and Gastropoda) of selected sites in Tubbataha Reef National Marine Park. Science Diliman 17 (2): 1–10.

Dolorosa RG, Jontila JBS (2012) Notes on common macrobenthic reef invertebrates of Tubbataha Reefs Natural Park, Philippines. Science Diliman 24 (2): 1–11.

Dolorosa RG, Balisco RAT, Bundal NA, Magbanua R (2015) Reef assessment in Cagayancillo, Palawan, Philippines. World Wildlife Fund Philippines, Quezon City Philippines, 23pp.

Estacion JS, Palaganas VP, Perez RE, Alaval MNR (1993) Benthic characteristics of islands and reefs in the Sulu Sea, Philippines. Silliman Journal 36 (2): 15–41.

Foyle TP, Bell JD, Gervis M, Lane I (1997) Survival and growth of juvenile fluted giant clams, *Tridacna squamosa,* in large-scale grow-out trials in the Solomon Islands. Aquaculture 148: 85–104.

Gasteiger E, Gattiker A, Hoogland C, Ivanyi I, Appel RD, Bairoch A (2003) ExPASy: the proteomics server for in-depth protein knowledge and analysis. Nucleic Acids Research 31: 3784–3788. https://doi.org/10.1093/nar/gkg563

GBIF (2020) GBIF occurrence download. https://doi.org/10.15468/dl.6dee2h. Accessed on: 2021-01-26.

Gomez ED, Alcala AC (1988) Giant clams in the Philippines. In: Copland JW, Lucas JS (Eds.) Giant clams in Asia and the Pacific. Australian Centre for International Agricultural Research, Canberra, Australia, 51–53pp.

Gonzales BJ, Dolorosa RG, Pagliawan HB, Gonzales MMG (2014) Marine resource assessment for sustainable management of Apulit Island, West Sulu Sea, Palawan, Philippines. International Journal of Fisheries and Aquatic Studies 2: 130–136.

Gonzales BJ, Galon W, Dangan-Galon F, Becira J, Pagliawan H, Rodriguez E, Bactol GP, Venturillo R (2015) Resource assessment for fish sanctuary establishment, Saint Paul Bay, Western Palawan, Philippines. Technical Report. Western Philippines University, Puerto Princesa City, Philippines. https://www.researchgate.net/publication/299489402. Accessed on: 2020-8-15.

Gomez ED, Mingoa-Licuanan SS (2006) Achievements and lessons learned in restocking giant clams in the Philippines. Fisheries Research 80 (1): 46–52. https://doi.org/10.1016/j.fishres.2006.03.017

Gomez ED, Cabaitan PC, Vicentuan KC (2006) Coral culture and transplantation and restocking of giant clams in the Philippines. In: Primavera JH, Quinitio ET, Eguia MRR (Eds.) Proceedings of the regional technical consultation on stock enhancement for threatened species of international concern. Aquaculture Department Southeast Asian Fisheries Development Center, 13–15 July 2005, Iloilo, Philippines 39-48pp.

Hean RL, Cacho OJ (2002) Farming giant clams for the aquarium and seafood markets: A bioeconomic analysis. In: Proceeding of the 2002 Conference of the Australian Agricultural and Resource Economics Society (46th), Canberra, Australia, 125108.

Hernawan UE (2012) Taxonomy of Indonesian giant clams (Cardiidae, Tridacninae). Biodiversitas 13: 118–123. https://doi.org/10.13057/biodiv/d130303

Huelsken T, Keyse J, Liggins L, Penny S, Treml EA, Riginos C (2013) A novel widespread cryptic species and phylogeographic patterns within several giant clam species (Cardiidae: Tridacna) from the Indo-Pacific Ocean. PLoS ONE 8 (11): e80858. https://doi.org/10.1371/journal.pone.0080858

Juinio MAR, Meñez LAB, Villanoy CL, Gomez ED (1989) Status of giant clam resources of the Philippines. Journal of Molluscan Studies 55: 431–440.

Juinio-Menez MA, Magsino RM, Ravago RG, Yu ET (2003) Genetic structure of *Linckia laevigata* and *Tridacna crocea* among the Palawan shelf and shoal reefs. Marine Biology 142: 717–726.

Lagpas AJ, Habito CDI (2016) Ecosystem services of coastal and fisheries resources: Perspectives of high school students in Municipality of Panukulan, Polillo Island, Quezon, Philippines. Journal of Marine and Island Cultures 5 (2):145–148. https://doi.org/10.1016/j.imic.2016.09.005

Lebata-Ramos MJHL, Okuzawa K, Maliao RJ, Abrogueña, Dimzon MDN, Doyola-Solis EFC, Dacles TU (2010) Growth ad survival of hatchery-bred giant clams (*Tridacna gigas*) in an ocean nursery in Sagay Marine Reserve, Philippines. Aquaculture International 18: 19–33.

Mecha NJ, Dolorosa RG (2020) Searching the virtually extinct *Tridacna gigas* (Linnaeus, 1758) in the Reefs of Palawan, Philippines. The Philippine Journal of Fisheries 27 (1): 1–18. https://doi.org/10.31398/tpjf/27.1.2019-0005

Munro JL (1989) Fisheries for giant clams (Tridacnidae: Bivalvia) and prospects for stock enhancement. In: Caddy JF (Ed.) Marine invertebrate fisheries: their assessment and Management. Wiley, New York, USA, 541–558.

Naguit MR (2009) Characterization of the siphonal mantle of *Tridacna crocea*. The Threshold 4: 4–5.

Naguit MR (2015) Genetic patterns of *Tridacna crocea* in the Bohol Sea. NMSCST Research Journal 3 (1): 10–11. http://orcid.org/0000-0002-9304-9246

Neo ML, Eckman W, Vicentuan K, Teo SLM, Todd P (20150 The ecological significance of giant clams in coral reef ecosystems. Biological Conservation 181: 111–123. http://doi.org/10.1016/j.biocon.2014.11.004

Nuryanto A, Duryadi D, Soedharmaand D, Blohm D (2007) Molecular phylogeny of giant clams based on mitochondrial DNA cytochrome C Oxidase I gene. Hayati Journal of Bioscience 14 (4): 162–166. https://doi.org/10.4308/hjb.14.4.162

Ravago-Gotanco RG, Magsino RM, Juinio-Meñez MA (2007) Influence of the north equatorial current on the population genetic structure of *Tridacna crocea* (Mollusca: Tridacnidae) along the eastern Philippine seaboard. Marine Ecology Progress Series 336: 161–168. https://doi.org/10.3354/meps336161

Santiago JA, Castillo RV, Creencia L, Lagman MCA (2020) Updates on the status of *Tridacna crocea* in the Philippines with notes on molecular approach analysis. In: Proceedings of the DLSU Research Congress 2020, Manila, Philippines, SEE-06: 1–6.

Shorthouse DP (2010) SimpleMappr, an online tool to produce publication-quality point maps. https://www.simplemappr.net. Accessed on: 2020-6-26.

ter Poorten JJ (2009) The Cardiidae of the Panglao Marine Biodiversity Project 2004 and the Panglao 2005 Deep-Sea Cruise with descriptions of four new species (Bivalvia). Vita Malacologica 8: 9–96.

Walsh PS, Metzger DA, Higuchi R (1991) Chelex 100 as a medium for simple extraction of DNA for PCR-based typing from forensic material. BioTechniques 10: 06–513.

Wells SM, Pyle RM, Collins NM (1983) The IUCN invertebrate

red data book. International Union for Conservation of Nature, Gland, Switzerland, 351–354.

Wells SM (1997) Giant clams: status, trade and mariculture, and the role of CITES in management. International Union for Conservation of Nature, Gland, Switzerland, 77 pp.

Yamaguchi M (1996) Shallow water molluscan assemblages of the Tubbataha Reef, Republic of the Philippines. In: The report of the project for resources survey and conservation of Tubbataha Reefs National Marine Park. DENR and Marine Parks Center of Japan, Quezon City, Philippines, 61–71pp.

Yu ET, Juinio-Meñez MA, Monje VD (2000) Sequence variation in the ribosomal DNA internal transcribed spacer of *Tridacna crocea*. Marine Biotechnology 2 (6):511–516. https://doi.org/10.1007/s101260000033